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The legacy of Newton for the pre-Critical Kant

Michela Massimi

1. Introduction

Newton's far-reaching influence for Kant's philosophy of nature is well documented, and has rightly been at the center of an important literature. No one more than Kant was responsible for placing Newton's natural philosophy center-stage in the philosophical *milieu* of the eighteenth century. Yet no one more than Kant had a complex and nuanced approach to some key aspects of Newtonian science. While much ink has been spilled over Kant's allegiance to Newton in the Critical period,¹ Kant's early acquaintance with Newtonianism has not received a similar degree of attention.² Yet the pre-Critical period is key to understanding the formation and evolution of some seminal ideas of Kant. The pre-Critical period can also reveal the idiosyncratic blend of intellectual traditions and scientific sources, which is so distinctive of the early Kant. The goal of this chapter is to offer a very brief survey of Newton's legacy for the pre-Critical Kant (i.e. before the *Inaugural Dissertation* of 1770).

Over the past three decades, important work has been done to clarify how Kant's view of geometry and mathematics³ was inspired by Newton, as much as his mature view on Dynamics and Mechanics seems to have been shaped upon Newtonian mechanics. This trend in Kantian studies mirrors a similar one in Newton studies, where scholars have paid increasing attention to the broader philosophical project surrounding Newtonian science.⁴ Was Kant an unfailing supporter of Newton all along? Should we read Kant's philosophy of nature as providing a systematic philosophical framework for Newtonian science?

While it cannot be gainsaid that Newton played a key role in influencing the young Kant and his (early and mature) reflections on nature, the answers to the two questions above are not as platitudinous as they may seem. For Kant's philosophy of nature

¹ See Friedman (1992a) and (2013); Plaass (1965); Pollok (2001); Smith (2013b); Tuschling (1971); Warren (2010); and Watkins (1998a), (1998b), (2001) just to mention a few examples.

² For some relevant exceptions, see Adickes (1924); Grillenzoni (1998); Polonoff (1973); Schönfeld (2000); Tonelli (1959); Watkins (2005).

³ See for example DiSalle (2006); and Domski (2013).

⁴ See Janiak (2008); Janiak and Schliesser (2012); Brading (2012); and Schliesser (2011), among others.

evolved and developed over time, from his very early contributions in the 1750s, to his mature Critical period. Any accurate answer to the question as to whether Kant was an unfailing supporter of Newton would require a systematic investigation of particular phases within Kant's vast intellectual production, and a detailed analysis of the historical context behind it.

The presence of distinctive Newtonian elements in Kant's writings on natural science oscillates significantly even within a single phase of his productive career. Just to confine our attention to the pre-Critical writings, Newton and Newtonian themes were absent in Kant's first work *Thoughts on the true estimation of living forces* (1748). They appear in what some scholars have portrayed as Kant's 'conversion to Newton' in *Universal Natural History and Theory of the Heavens* (1755), whose subtitle reads "An essay on the constitution and mechanical origin of the whole universe treated according to Newton's principles". Yet Newtonian themes seem again marginal in Kant's defense of relationalism about space in *New doctrine of motion and rest* (1758), which in turn seems in stark contrast with Kant's seeming advocacy of absolute space in *Directions in Space* (1768).

Kant's attitude towards Newton's mechanics and natural philosophy should be read against the backdrop of the scientific panorama of the time, in particular the scientific sources available to Kant (first-hand or second-hand) via the Leipzig-based *Acta Eruditorum*, or the proceedings of the *Berlin Royal Academy of Sciences*. We can only reconstruct these sources from explicit references in Kant's early writings. At a glance, these sources reveal that the young Kant was mostly (but not exclusively) acquainted with Newton second-hand. Namely, the Newton, who had either been targeted in Leibnizian–Wolffian quarters, or celebrated by British natural philosophers and Newtonian supporters in the Continent (especially, in France and in the Netherlands). This is possibly a different Newton from the one we are so accustomed to. Thus, reconstructing Newton's legacy for the early Kant's philosophy of nature can be a daunting exercise at the key junction of Kantian studies, intellectual and social history of science, as well as history of philosophy.

Important work has been done to assess the nuanced legacy of Newton for Kant's philosophy of nature, in particular for Kant's view on the laws of nature. Buchdahl⁵ famously argued for the so-called 'looseness of fit' between Kant's transcendental apparatus and the foundations of physical science against the standard view, which for

⁵ Buchdahl (1974).

long time had maintained a strict link between the two. For example, the role of the category of quality in providing a priori justification for Kant's Dynamics in *MAN* was challenged.⁶ The empirical laws of Newtonian mechanics were regarded as established not top-down (from the Principles of the Transcendental Analytic) but bottom-up, from the special metaphysics of nature, and in particular from the empirical concept of matter. Since the early 1990s, against both the standard view and Buchdahl's 'looseness of fit' interpretation, Friedman has argued that Kant's transcendental project should be read as providing the philosophical groundwork for Newton's physics.⁷ What is at stake in Friedman's interpretation is neither the contentious view that the lawfulness of nature under the transcendental laws of the understanding (e.g., causality, for example) per se guarantees or licenses empirical laws of nature. Nor that empirical laws are known a priori, like their transcendental counterparts. Instead, on Friedman's view, something like the a priori principle of causality has to be in place for us to recognize a sequence of events or uniformities in nature as lawlike (pace Hume), even if particular laws of nature can only be empirically discovered.

While the debate surrounding the standard view, the looseness of fit and Friedman's own interpretation addresses the overarching issue of how Kant's transcendental philosophy relates to his philosophy of nature, a myriad of questions can be raised about specific aspects of Kant's philosophy of nature and its debt to Newton. For example, are Kant's laws of mechanics in *MAN* somehow patterned upon Newton's laws of motion? The answer is far from obvious. For example, Watkins has argued for a reappraisal of Leibnizian influences instead.⁸ Stan has in turn documented how Kant's third law of mechanics had its origins in Leibniz's Reaction Principle, and its later incarnations in the work of Jacob Hermann and Christian Wolff (as opposed to Newton's third law).⁹ Pre-Newtonian aspects of Kant's conception of force (back to *True estimation of living forces*) have been brought to the fore to understand Kant's famous balancing argument for attraction and repulsion in the Chapter on Dynamics in *MAN*.¹⁰ Anti-Newtonian aspects have also been found in Kant's *Universal Natural History*,

⁶ For further details on this point and a critical discussion of the standard view, see Watkins (1998B).

⁷ Friedman (1992a), (1992b), (2013).

⁸ Watkins (1998a) rightly notes that Newton's second law is absent among Kant's laws, and even Kant's formulation of the law of inertia is effectively different from Newton.

⁹ Stan (2013).

¹⁰ Warren (2010). Contra Warren, Smith (2013a) has defended a Newtonian reading of the balancing argument.

whereby the order and lawfulness of nature is not ascribed directly to God's hand but to matter and its necessary laws.¹¹ Similar anti-Newtonian sentiments, this time along Spinoza's lines, have been recounted in *Universal Natural History*.¹² And Cartesian echoes present in Kant's first essay on *True estimation of living forces* have also received recent attention.¹³ As these few examples show, Newton's legacy for Kant is a very nuanced territory to chart.

Given the complexity of the historical background and the variety of themes in Kant's philosophy of nature, in what follows I make a very selective choice. I concentrate exclusively on the early Kant around 1748–1768. And even within this twenty-year span, I selectively pay attention to only a handful of Kant's writings and one specific (but hopefully revealing) aspect of Newton's legacy for Kant: the evolution of Kant's view of space. The received view has it that in the pre-Critical period Kant shifted from an originally Leibnizian / relationalist view of space (still evident in *Physical Monadology* and *New doctrine of motion and rest*, 1758) to a proper Newtonian view of absolute space via the incongruent counterparts argument of *Directions in Space* (1768), for then abandoning absolute space in the *Inaugural Dissertation* (1770).¹⁴ Indeed, Kant famously criticized Newton's absolute space (as well as Leibniz's relationalism) in the *Critique of Pure Reason*¹⁵ in the name of transcendental idealism. And the same argument from incongruent counterparts was later employed in the *Prolegomena* as an argument for space as “the form of outer intuition of [...] sensibility”.¹⁶ In what follows, I take some preliminary steps towards challenging this received view of the evolution of Kant's view of space in the period 1748–1768.

I have two main goals in mind: the first historical, and the second philosophical. First, I want to draw attention to the role that Newton's matter theory and chemistry played for the young Kant. Without denying the importance of the *Principia* for Kant, there is yet another Newton—a more experimental Newton, who speculated about the ether and chemical reactions in the Queries of the *Opticks*—that in my view has not

¹¹ Watkins (2013).

¹² Schliesser (2013).

¹³ Massimi and De Bianchi (2013).

¹⁴ To be precise, absolute space did not disappear entirely in the Critical period. Indeed, it reappears for example in the General Remark to Phenomenology in *MAN* as a necessary concept of reason.

¹⁵ Kant (1781/1787/1997): A23/B37. As it is custom, the A refers to the first (1781) edition and the B to the second (1787) edition.

¹⁶ AA 4:286. Kant (1783/2004 2nd ed.).

received the full attention he deserves by Kant scholars¹⁷ (despite being well-known among historians of science). In my view, the speculative Newtonian experimentalism of the first half of the eighteenth century can cast interesting new light on the possible legacy of Newton on Kant, and can help reassess some vexed issues.

I have argued elsewhere, for example, that some puzzling aspects of Kant's view of repulsive force (still evident in *MAN*) can be explained against the backdrop of Newtonian experimentalism. For Kant's claim that repulsive force comes in degrees in different matters such as air, ether, and heat, among which the same attractive force is active, can be easily explained if we take repulsion as an original elastic force (whose physical seat or repository consisted in some material carrier—be it air or ether—following Newton's pre-*Principia* matter theory, and Newtonians such as Stephen Hales and Herman Boerhaave).¹⁸ Similarly, Kant's puzzling claim in the Third Chapter of *MAN* that all mechanical laws presuppose dynamical laws, and matter cannot have moving force except by means of attraction and repulsion¹⁹ can receive new light if understood against the background of Kant's early engagement with the *vis viva* debate; and, in particular, his defense of the Cartesian Dortous de Mairan against the Leibnizian Du Châtelet in the 1740 controversy. In what follows, I draw attention to yet another role for Newton's matter theory in shaping another key aspect of Kant's philosophy of natural science: *space*.

Thus, my second (more philosophical) goal is to urge a note of caution against the received view that has portrayed Kant as sitting squarely within the Newtonian tradition from the very beginning. If by "Newtonian tradition", we mean the Newtonian mechanics of the *Principia* and the ensuing tradition in mechanics that developed out of it, there seems to be evidence to suggest a more nuanced reappraisal of this claim. The case of absolute space is illuminating. Did the young Kant convert to Newton's absolutism (ca. 1768), short-lived as the conversion proved to be? In what follows, I take some steps towards answering this question in a negative way. I show that in the relevant period around 1748–1768, Kant was working with a thoroughgoing relational view of space, naturally ensuing from Kant's matter theory of around 1755. While sufficiently

¹⁷ A notable exception is Carrier (2001), for example. See also McNulty (2014).

¹⁸ I have offered my interpretive analysis of these Newtonian origins of Kant's repulsive force in *Universal Natural History* in Massimi (2011), and I refer the interested reader to that paper for further details on this topic.

¹⁹ AA 4: 537. Kant (1786/2004). For the influence of this earlier debate on *vis viva* on Kant's *True estimation* and its lingering echoes in the aforementioned passage of *MAN*, see Massimi and De Bianchi (2013).

distant from both Leibniz's and Wolff's relationalism, Kant's view of space was elaborated primarily against the backdrop of the Leibnizian–Wolffian tradition²⁰ and of Kant's new dynamical theory of matter, which was, in turn, inspired by speculative Newtonian experimentalism.

In Section 2, I offer a brief overview of the historical context to assess Newton's legacy on the young Kant, by paying attention to the role of the *Opticks* in the first half of the eighteenth century and to Continental Newtonianism. In Section 3, I turn to the philosophical question as to whether the pre-Critical Kant around 1748–1768 did in fact endorse Newton's absolute space, before turning to transcendental idealism. I make some remarks, which—tentative as they might be—suggest, nonetheless, a more cautious answer to the question.

2. The pre-Critical Kant and its Newtonian *milieu*

Before making my case for a nuanced picture of Newton's impact on the pre-Critical Kant, it may be worth recalling briefly the intellectual context in which the young Kant was educated and trained,²¹ and draw attention to the wider Newtonian context of the first half of the eighteenth century. As Isaac Bernhard Cohen originally pointed out,²² two very different Newtonian traditions were present at the time: the experimental Newtonianism, typical of the *Opticks* (first English edition 1704; first Latin edition 1706, and second English edition 1717); and the mathematical Newtonianism, more evident in the *Principia* (first edition 1687, second edition 1713, third edition 1726).²³ In the first Latin edition and the second English edition of the *Opticks*, Newton introduced two sets of Queries, where he relegated the most general, often highly speculative, principles that could be inductively drawn from observations and experiments. Among them, the ether

²⁰ For an excellent reconstruction of how Kant's matter theory of this period, especially evident in *Physical Monadology*, borrows from and, at the same time, distances itself from Leibniz, Wolff, and also Baumgarten, see Watkins (2006).

²¹ See Pozzo and Oberhausen (2002) and Kuehn (2001).

²² Cohen (1956). For a more recent, and somehow antithetic trend about Newton's legacy in the Continent (especially in relation to chemistry), see Principe (2007)

²³ Of course, this broad methodological distinction between the *Opticks* and the *Principia* does not capture important nuances, i.e. experimental aspects present in the *Principia*, for example, and mathematical stages present in the *Opticks* (I thank Chris Smeenk for raising this point). More recently, Ahnert (forthcoming) has made a similar point about the separation of Newton's mathematics from Newton's natural philosophy and why the latter spread more successfully in the German-speaking countries. Not only was Newton's mathematics too complex to be taught in Philosophy Faculties; Newton's mathematics was also regarded as lacking a proper metaphysical foundation.

featured prominently as a medium for the explanation of gravity, optical, thermal, and even electrical phenomena.

In the first edition of the *Principia* Newton argued against the ether and provided a mathematical treatment for the behavior of elastic fluids, which did not require any subtle matter.²⁴ But the hypothesis of the ether returned prominently in the Queries of the *Opticks*, after a premature appearance in Newton's pre-*Principia* matter theory.²⁵ The existence of a very subtle ether was introduced to explain how light was refracted and reflected, as well as the transmission of heat among bodies (Query 18), and a possible gravitational mechanism for planetary motion (Query 21).²⁶ In addition to the ether, speculations about chemical phenomena, metal combustions (with the ensuing release of 'true permanent air') and fermentations of various substances too featured in the Queries of the *Opticks*. In Query 31, for example, Newton famously introduced the two active principles of attraction and repulsion, as the "cause of Gravity" and the "cause of Fermentation", respectively,²⁷ through which matter in the universe was said to be continuously preserved from decaying. Repulsive force was associated with chemical phenomena of fermentations, through which air (*qua* physical seat of repulsive force, trapped in the pores of various substances) would be released.

A time-honored historiographical tradition has long emphasized the role that the Newtonian experimentalism of the *Opticks*—with its speculations on fermentations, chemical reactions with *Aqua fortis*, and the ether—exercised on the natural philosophy of the first half of the eighteenth-century.²⁸ According to this historiographical tradition,

²⁴ See Book II, Proposition XXIII, Theorem XVIII of the *Principia* for example.

²⁵ See Newton's famous letter to Boyle (28 February 1678-9) published in Boyle (1744), and the pre-*Principia* text *De Aere et Aethere* (written probably around 1674). Newton's speculations on the ether took the lead from Boyle's experimental tradition (especially, Boyle's experiments on calcination of metals). In *De Aere et Aethere*, Newton claimed that air was composed of particles repelling each other with a certain force. In the letter to Boyle, repulsive force was re-assigned from the air to the ether, and the rarefaction of the ether was taken to be responsible for the endeavor of bodies to recede.

²⁶ Similar attempts to use the ether as a gravitational mechanism can be found in Descartes's vortex theory, Leibniz's continuum elastic ether (in the *Tentamen* written in response to Newton's first edition of the *Principia*), as well as in Euler. For a survey of ether theories at the time, see Aiton (1972).

²⁷ Newton (1704/1717/1752), Query 31, p. 395

²⁸ This historiographical trend began with the work of Metzger (1930), and Guerlac (1950) and Cohen (1956). For a recent dissenting voice, see Principe (2007). It is beyond my expertise and my aim here to enter into this historiographical debate. My concern here is not so much about which chemical school proved more influential in the Continent in the first half of the eighteenth century, but rather which Newtonian aspects can be found in the pre-Critical Kant's reflections on natural philosophy.

more than Newton's mechanics in the *Principia* (whose mathematical language and technical results demanded a level of knowledge not easily available at the time), it was Newton's chemistry and matter theory in the *Opticks* that had a far-reaching influence for natural philosophy both in Britain and in the Continent at the time.

In Britain, the *Opticks* influenced the work of an entire generation of iatrochemists, including the brothers John and James Keill,²⁹ while the publication of Newton's letter to Boyle on the ether (28 February 1678) in Thomas Birch's edition of Boyle's works played a key role in establishing Newton's speculations on the ether as Newton's orthodox matter theory. Another key textbook that marked the triumph of the speculative Newtonian experimentalism of the *Opticks* was Stephen Hales' *Vegetable Statics* (1727). Hales latched onto Newton's discussion of attraction and repulsion, and picked up on Newton's pre-*Principia* identification of the air as the physical seat of repulsive force. He defended what he called "elastick air", trapped in the pores of mineral, vegetable and animal substances, and released upon fermentation or combustion. *Vegetable Statics* won acclaim in British Newtonian quarters and beyond. Desaguliers wrote a very positive review in the *Philosophical Transactions*,³⁰ where he presented it as the best confirmation for Newton's Queries. The book was translated first into French, and then into German with a Preface by Christian Wolff in 1748, and had a far-reaching influence on the Continent, especially on the Dutch Newtonianism that flourished in Leiden under Herman Boerhaave.

Newtonianism spread in the Continent in the early eighteenth century not without some resistance from Cartesian and Leibnizian quarters. France proved a hostile environment for experimental Newtonianism, with Edme Mariotte's firm resistance against Newton's theory of colours.³¹ By contrast, Holland provided a fertile territory for experimental Newtonianism, after the advent of Wilhelm of Orange in 1688, and the ensuing strengthened cultural links with England. The Dutch natural philosopher 's Gravesande, for example, came to England as ambassador to the first Hanoverian King George I, and was elected Fellow of the Royal Society. Upon his return to Leiden, 's Gravesande obtained the Chair of Astronomy and Mathematics, and his 1720 textbook *Physices elementa mathematica* was soon translated into English by Desaguliers. Like Hales

²⁹ John Keill's *Introductio ad veram physicam* (1702) was originally written as a set of lectures, and became soon one of the standard textbooks on natural philosophy, with six Latin editions, an English translation in 1720, and six further English editions (See Schofield, 1970, p. 27).

³⁰ See Schofield (1970), p. 81.

³¹ See Guerlac (1981), p. 100ff.

after him, 's Gravesande went back to the pre-*Principia* Newtonian theme of the air as the physical seat of repulsion, while fire was considered to be a subtle material substance contained in all bodies. The idea of fire as a subtle, fluid substance was also defended by Pieter von Musschenbroek, the discover of the Leyden jar, and Chair of Mathematics and Philosophy at Utrecht from 1723, and then in Leiden in 1740. Musschenbroek's main text *Elementa Physicae* (1741) became the standard textbook of experimental natural philosophy, and was soon translated into English in 1744, and into German in 1747.

But, undoubtedly, the key figure in the thriving community of Dutch Newtonians³² was Herman Boerhaave, Professor of Chemistry in Leiden (from 1718 until his death in 1738). Building on Hales' *Vegatable Staticks*, in *Elementa Chemiae* (1732), Boerhaave defended the view that fire was a very subtle material fluid—similar to Newton's ether—present in all bodies and responsible for their states of physical aggregation.³³ Moreover, just like Hales' "elastick air", Boerhaave's material fire too was an elastic matter fixed in the pores of all substances and able to rarefy them in virtue of its repulsive power acting by direct contact.³⁴

I have argued elsewhere³⁵ that the elaboration of Kant's dynamical theory of matter around 1755—as evident in *Universal Natural History* and *On Fire*—owes a great debt to this British–Dutch experimentalist tradition. A central aspect of Kant's pre-Critical dynamics (somehow retained also in the Critical period with provisos) is the treatment of repulsive force as a contact force acting as an elastic fluid surrounding matter's parts. In the next Section, I argue that this same Newtonian experimentalist tradition influenced also Kant's view of space in the pre-Critical period around 1748–1768. The received view maintains the following three theses:

- (i.) the pre-Critical Kant embraced Newtonianism since the very beginning of his career (back to *True estimation* in 1748);
- (i.) Kant temporarily endorsed a form of relationalism about space in *Physical Monadology* (1756);
- (ii.) But in *Directions in space* (1768), Kant turned his back to relationalism to defend instead Newton's absolute space via the argument from incongruent counterparts.

³² On the Leiden Newtonian school surrounding Boerhaave, see Ruestow (1973).

³³ Boerhaave (1732 /1735), vol. I, pp. 104–113.

³⁴ Metzger (1930), p. 56, identified Boerhaave as the main source behind Boscovich's dynamical theory of matter, whereby attraction is understood in terms of gravitation and repulsion in terms of imponderable fluids such as caloric.

³⁵ See Massimi (2011).

In what follows, I suggest that the way Kant came to elaborate his view of space from *True estimation* to *Directions in space* betrays once more his idiosyncratic blend of the Wolffian and the Newtonian traditions. In particular, it reveals the far-reaching influence of Newton's matter theory and chemistry on a still broadly Wolffian-relationalist framework. I argue for the following three points:

(i.a) Pace (i.), Kant's view of space in *True estimation* borrows from Wolffian metaphysics of monadic substances and their mutual actions.

(ii.a) The relationalism advocated in *Physical Monadology* is at some distance from both Leibniz and Wolff, and betrays Kant's debt to speculative Newtonianism in the treatment of physical monads as spheres of activity (with repulsion again understood as a contact force and exemplified by the "ether, that is to say, the matter of fire"),³⁶ notwithstanding thesis (ii.)

(iii.a) Finally, Kant's enthusiasm for Newton's programme in *Directions in space* requires a few caveats, and, in my view, should be read instead as containing the seminal seeds of Kant's later Critical treatment of space.

In the next Section, I go on to substantiate points (i.a)–(iii.a).

3. The pre-Critical Kant on space.

Beyond Wolffian relationalism and Newtonian absolutism

One topic where the young Kant's debt to Newton's natural philosophy emerges vividly is the nature of space. In the General Scholium added to the second edition of the *Principia* (1713), Newton famously defended absolute space as the expression of God's omnipresence in the world. In 1720, the Leibniz–Clarke correspondence appeared in a German translation with a Preface by Christian Wolff, making the debate available to the German-speaking community. Twenty-six years later, in 1746, Euler published a trenchant critique of Leibniz's monadology entitled *Thoughts on the Elements of Corporeal Entities*, and monadology was again the topic of the 1747 Berlin Academy prize essay

³⁶ AA I: 487. Kant (1756/1992).

competition.³⁷ At stake in the debate between friends and foes of monadology was the vexed question as to whether matter consisted of simple, non-extended elements, or indivisible monads, endowed with primitive inherent forces (what Leibniz called *vis activa*). Leibnizian dynamics³⁸ aimed to explain physical phenomena, such as elastic collisions between bodies, in terms of *derivative forces*, somehow correlated to the primitive forces of the non-extended simple monads. The post-Leibnizian tradition, with Wolff first and Baumgarten then, elaborated Leibniz's monadology along new important lines.³⁹ In *Philosophia prima; sive Ontologia* Wolff reflected on the role of monads (qua simple elements) in the analysis of the compositionality of bodies and their spatial divisibility. In *Metaphysica* Baumgarten, in turn, was the first to regard monads as 'physical' and endowed with impenetrability. Although Baumgarten's 'physical monads' represented an important departure from Leibniz's (and Wolff's) monads, Baumgarten was still trapped into a fully Leibnizian mode in thinking that the interactions between physical monads were explained by pre-established harmony. Baumgarten's impenetrable 'physical monads' lack genuine physical modes of interactions.

It is in this intellectual climate that the young Kant wrote his very first essay on the *True estimation of living forces*.⁴⁰ Kant's goal was to investigate the cause of motion within a broadly Leibnizian–Wolffian framework. Following a well-trodden path that Wolff had originally opened by reinterpreting Leibnizian monads as amenable to interactions among each other, Kant introduced the idea that substances must exercise their forces in space and time, with time defined as “the succession of things”, and space as the “coexistent states of the world”.⁴¹ Substances have active forces and cannot remain inactive. As such they exercise their forces by acting on one another and changing the internal states of other substances. The exercise of forces occurs in space and time. While the language of things coexisting *in* space and succeeding one another *in* time might sound reminiscent of Newton's absolute space and time as the ultimate containers of everything that exists, nothing could in fact be more remote from it.

³⁷ See Ahnert (forthcoming).

³⁸ See Leibniz (1695 /1969).

³⁹ For an excellent analysis of this debate on the nature of monads from Leibniz, to Wolff, Baumgarten and the pre-Critical Kant, please see Watkins (2006).

⁴⁰ Kant (1747 / 2012).

⁴¹ AA 1: 19. Kant (1747/2012), pp. 23, 24. The relationalist view of space *qua* “coexistence” of substances can be found in Wolff's *Philosophia prima, sive Ontologia*. For a discussion of Wolff and Newton, see Stan (2012), p. 463.

For, as Kant points out later in the text, “it is easy to show that there would be no space and no extension if substances had no force to act external to themselves. For without this force, there is no connection, without connection, no order, and finally, without order, no space. Yet it is somewhat more difficult to see how the plurality of dimensions in space derives from the law according to which this force of substances acts externally”.⁴² Kant’s working hypothesis was not Newton’s absolute space as a privileged reference frame for bodies in motion, but instead the Wolffian *nexus rerum*. Thus, pace claim (i.) it is not the case that Kant embraced Newtonianism from the very beginning. He was instead working with a thoroughly Wolffian metaphysics of monadic substances and their mutual actions. The challenge for the young Kant consisted in explaining how the three-dimensionality of space could follow from this still broadly Wolffian metaphysical dynamics. More precisely, the main challenge facing Kant was to spell out the mechanism through which substances endowed with active forces could exercise their powers in *space and time*, qua *physical* space and time. And the challenge could only be met by following Baumgarten’s intuition and developing it further: i.e. by making substances (and their interactions) *physical*.

Kant addressed this challenge a few years later in *Physical Monadology*. In this 1756 text, Kant went back to the idea of reciprocally acting substances, this time described as physical monads. Kant’s ambitious task was to reconcile the infinite divisibility of space with the view of metaphysically simple, non-divisible elements of bodies. For the infinite divisibility of space, Kant took his cue from the Newtonian John Keill, who in the 1720 English edition of *An Introduction to Natural Philosophy* had famously challenged those philosophers, who while readily allowing mathematical bodies to be infinitely divisible, denied nonetheless the infinite divisibility of physical bodies.⁴³ Keill’s proof for the infinite divisibility of bodies proceeded by assuming that given two parallel lines and given two points A and B lying on these parallel lines along the vertical A–B, it was possible to divide the vertical line A–B by drawing an infinite number of lines, all originating from one point C (located on the left hand side of point A on the top line), to an infinity of points E–F–G–...(located on the right hand side of point B on the bottom line).

In *Physical Monadology* Kant went back Keill’s proof. Yet he reached the diametrically opposite conclusion that the infinite divisibility of space was in fact

⁴² AA 1: 23. Kant (1747/2012), pp. 26-27.

⁴³ Keill (1726, 2nd ed.), pp. 30-31.

consistent with the assumption that bodies consisted of a determinate number of simple parts (Corollary. Proposition IV. Theorem).⁴⁴ Kant motivated his stark conclusion on the ground that “space, which is entirely free from substantiality and which is the *appearance of the external relations of unitary monads*, will not at all be exhausted by division continued to infinity”.⁴⁵ While bodies are compounded of many simple elements (physical monads) that cannot be divided infinitely (on pain of contradicting the very principle of composition), the space taken up by bodies is itself infinitely divisible. The infinite divisibility of the geometrical space did not align with the finite divisibility of material compounds, because—Kant argued—space was not itself a substance or a physical entity amenable to composition. Parts of space lacked existence of their own.

By denying substantiality to space, Kant could endorse without contradiction both Keill’s proof of the infinite divisibility of space and an improved Wolffian–Baumgartian version of monadology. Newtonians erred in waving Keill’s proof against the “metaphysicians”, as much as the “metaphysicians” erred in maintaining against the “geometers” that the properties of space were imaginary. Key to this rapprochement was Kant’s view of space as “a certain appearance of the external relations of substances”, whereby plurality and division would not jeopardize the unity of the substances itself. But how should we understand Kant’s view of space as an appearance of external relations among substances? How do substances mutually interact, and how does space result from their interactions? Kant’s answer to these questions was in terms of ‘sphere of activity’—physical monads fill space not through the composition of their substantial parts, but instead via their spheres of activity.

The previous notion of space as ensuing from the reciprocal actions of substances⁴⁶ finds its ultimate expression in a dynamical scenario of physical monads as point-like entities surrounded by spheres of activities, through which space is filled. Following Baumgarten, Kant called the force through which physical monads fill the space “impenetrability”, as a fundamental repulsive force acting by direct contact among elements of any body. In Kant’s picture, space was constituted by the action and reaction of simple elements of bodies or physical monads. Their respective spheres of activity were in direct contact via repelling forces responsible for filling the space by making

⁴⁴ AA 1: 478–480. Kant (1756/1992).

⁴⁵ AA 1: 479. Kant (1756/1992).

⁴⁶ See on this point also *New Elucidation*, where Kant spelled out his view of space as being constituted by the “interconnected actions of substances, reaction always being of necessity conjoined with such interconnected actions” AA1: 415. Kant (1755b/1992).

physical monads recede from each other, while attractive forces among their centers of mass would counterbalance their endeavor to recede.⁴⁷ Repulsive force explained how bodies resisted penetration by other bodies, while attraction secured the cohesion among bodies' simple elements, anticipating the famous balancing argument of *MAN*.

The dynamical balance of original forces of attraction and repulsion—via direct contact among the spheres of activity of simple elements—ultimately secured space as an appearance of external relations among substances. Thus, it would seem that Kant's view of space emerging from *Physical Monadology* is a form of relationalism in continuity with Leibniz, Wolff and Baumgarten in taking spatial properties as *relational* (as opposed to intrinsic) *properties* of substances. Under this reading, the infinite divisibility of space would not jeopardise the unity and simplicity of the monads because the divisibility of space would be confined to the divisibility of external relations among substances, and not their internal determinations, or intrinsic properties, which are not in space. Yet, there is a problem with this otherwise tempting relationalist reading of Kant's view of space; a problem, whose solution will reveal the importance, in my view, of Newtonian experimentalism for Kant's view of space. The problem is the following.

Suppose we take 'external determinations of substances' to be defined by the boundaries of the spheres of activity of metaphysical monads: i.e., the external relation between physical monad A and physical monad B is defined by the surface area (which may well reduce to one single point) where the sphere of activity of substance A touches or is in contact with the sphere of activity of the adjacent substance B. In other words, space is defined by the relation through which substance A (with its sphere of activity consisting of attractive and repulsive forces), respectively attracts and at the same time resists penetration from an adjacent substance B.

Given this picture, saying that the divisibility of space is restricted to the divisibility of substances' external relations implies that spatial divisibility cuts physical monads 'at their joints', so to speak, i.e. along the tangents to the points of contact among their respective spheres of activity. But how is this possible? This kind of spatial divisibility would be finite and discrete (cutting physical monads' joints) and at quite a distance from Keill's infinite geometrical divisibility that Kant has just defended.

⁴⁷ AA 1: 484. Kant (1756/1992). In *Universal Natural History*, just a year earlier, Kant had developed a dynamical cosmogony based on primitive attractive and repulsive forces applied to 'fine matter', which he thought must have filled the space at the origin of the cosmos. For a penetrating analysis of the way repulsive and attractive forces are balanced in Kant's physical monads and for its divergence from Boschovich, see Smith (2013b).

Here is then the problem: how can physical monads fill space via their spheres of activity, *and* space being infinitely divisible without:

- (a) either jeopardizing the simplicity and unity of the monads (pace monadology)
- (b) or reaching the contradictory conclusion that the divisibility of space (qua external relations among substances) can only be finite and discrete (i.e. along the boundaries of physical monads and their contact points, pace Keill's proof of the infinite divisibility of space).

In my view, this conundrum can be solved by bringing in considerations from Newtonian experimentalism; in particular, by considering Kant's *sui generis* treatment of repulsive force as a contact force through which physical monads fill space by resisting penetration from each other. I said *sui generis* treatment because in Proposition XI. Theorem, against the standard Newtonian view of specific density of bodies as the ratio between mass and volume, whereby bodies with the same volume may nonetheless possess different specific densities because of the different amount of interstitial vacua, Kant offered an alternative view. On Kant's view, bodies of different kinds (e.g. "ether, air, water, and gold") had different densities simply because they possessed different inherent inertia (or inertial mass) of their elements.⁴⁸ Specific densities were not explained by a greater or smaller vacuum interposed among the pores of different kinds of substances. For even the interstices of denser bodies, which are narrower, could be penetrated by less dense bodies such as "fire, and the magnetic and electric fluid", Kant argued. Instead, specific densities were due to a perfectly elastic force "which is different in different things", and which constituted "a medium which is, in itself and without the admixture of a vacuum, primitively elastic" (Proposition XIII. Theorem). As a primary example of elastic bodies, Kant mentioned the ether, "that is to say, the matter of fire", with an unequivocal homage to Boerhaave's material fire, in continuity with another of Kant's writings of this time, *On Fire*, where the ether was presented as both the matter of fire and the matter of light.⁴⁹

Thus, we see here exemplified an interesting way in which the view of space expounded in *Physical Monadology* borrows elements from the Newtonian experimentalist tradition. To avoid the aforementioned conundrum of either jeopardizing the simplicity and unity of the monads, or making the divisibility of space finite and discrete, Kant originally availed himself of a distinctively Newtonian experimentalist view of repulsive

⁴⁸ AA 1: 485- 486. Kant (1756/1992).

⁴⁹ For an analysis of *On Fire* see Massimi (2011).

force qua a perfectly elastic force, coming in different degrees in different kinds of materials (e.g., ether, air, water, gold). By understanding the impenetrability of bodies, and hence the boundaries of the spheres of activity of physical monads, as defined by the action of a perfectly elastic repulsive force, Kant could eschew the conundrum:

(a₁) the simplicity and unity of physical monads is safeguarded by thinking of space along relationalist lines, as a bunch of external relations holding among their respective spheres of activity.

(b₁) the infinite divisibility of space is guaranteed if we think of those impenetrable spheres of activities as a ‘force field’, the field of a perfectly elastic repulsive force that fills the space, like Boerhaave’s fire, electric and magnetic fluids, or ultimately, like the ether qua the subtle matter of fire and light.

Physical monads produce space via their external determinations, namely via their causal powers (attraction and repulsion). The continuity of space ensues from the continuity in the exercise of these causal powers (e.g. the continuous way in which the elastic force, as a subtle fluid, fills everything and acts by direct contact on other monads (with no vacua and no empty interstices). At the same time, just like a perfectly elastic subtle fluid that can be cut or sliced (so to speak) as one wishes, without destroying the simplicity or unity of the fluid itself, similarly Keill’s geometrical proof of the infinite divisibility of space could be reconciled with the unity and simplicity of the monads, without running the risk of cutting physical monads ‘at their joints’ and making spatial divisibility finite and discrete.

The Newtonian “geometers” (i.e. Keill) were reconciled with the “metaphysicians” (i.e. Leibniz, Wolff, Baumgarten) by recasting a loose relationalism about space (qua appearance of the external relations of substances) in dynamical terms. Kant’s allegiance to speculative Newtonian experimentalism (from Newton’s optical ether to Boerhaave’s material fire)—evident in Kant’s remarks on inertia and specific densities of bodies—made possible such a reconciliation.

But surely, the perceptive reader would object, Kant’s view on space underwent a significant change in subsequent years. While in the 1758 *New Doctrine of Motion and Rest*, Kant was still defending a form of relationalism about space, broadly consonant with his

Wolffian treatment of impact⁵⁰ against Newton's absolute space, Kant appeared to have changed his mindset in the following decade. In the 1768 *Concerning the ultimate ground of the differentiation of directions in space*, Kant seemed to side unequivocally with Newton and the Newtonians in rejecting the opinions of the "German philosophers", who claimed that space consisted solely in the external relations of the parts of matter. After all, twelve years after *Physical Monadology*, Kant clearly defended the view that directions in space could not be reduced to mutual relations among objects, but should be explained "in relation of the system of these positions to the absolute space of the universe".⁵¹ Is not Kant here embracing Newton's absolute space, with the famous argument for incongruent counterparts against Leibniz's relationalism? Is not he supporting the "geometers" in proving that "Absolute space, independently of the existence of all matter and as itself the ultimate foundation of the possibility of the compound character of matter, has a reality of its own"?⁵²

There are three clues in Kant's text, which in my view speak once again for a more nuanced debt to Newtonianism. For start, there is surprisingly no mention of Newton in the text. But this detail per se may not be very revealing. The question remains as to whether Kant was in fact defending Newton's absolute space; or, was he instead holding on to Newton's terminology, but devoid of its Newtonian connotations. I suggest that the latter option is more likely to be the case.

First, the declared goal of the essay was to offer a proof intended for "geometers" of the claim that absolute space has a reality of its own. Kant lamented, by tacitly referring to the Leibniz–Clarke correspondence, that no metaphysical argument had been successful in establishing this claim. Nor were a posteriori proofs for absolute space available, Kant claimed, apart from Euler's attempt to provide one for the prize essay of the Berlin Royal Academy of Sciences in 1748.⁵³ But Kant discarded Euler's as a proof intended for the engineers, not for "geometers". Moreover, Euler's proof was said to fail to engage with the difficulties arising when one tries to "represent [universal laws of motion] *in concreto*, employing the concept of absolute space".⁵⁴ Did Kant ignore Newton's own arguments for absolute space (i.e. the famous thought experiments concerning the bucket of water and the tied-globes)? Why does Kant say that there are

⁵⁰ For an interpretive analysis of this text, and its continuity with some of Kant's mature views on rotation and relative motion, see Stan (forthcoming).

⁵¹ AA 2: 377. Kant (1768/1992).

⁵² AA 2: 378. Kant (1768/1992).

⁵³ See Stan (2012), p. 465.

⁵⁴ AA 2: 378. Kant (1768/1992).

serious difficulties if we try to represent laws of motion *in concreto* by employing the concept of absolute space? Was not Newton's absolute space introduced precisely to ground the laws of motion and to provide a privileged reference frame to distinguish between inertial and non-inertial motions? Kant's complaint against Euler's proof (and perhaps Newton's one too) could be explained if read against the backdrop of Euler's distinction between the Metaphysicians, who denied that absolute space and time had any reality of their own, and the Mathematicians, who on the contrary considered space and place as real things. A charitable reading of Kant's above claim would then be that Euler's proof for absolute space cut no ice with the German metaphysicians because it presupposed precisely what the metaphysicians would question, namely the reality of absolute space.

Thus, with an eye to providing a *geometrical* proof for absolute space that could speak for the ear of the German metaphysicians, Kant drew attention to three different considerations:

- (I) We can have empirical knowledge of things outside ourselves only insofar as these things entertain a particular relation to ourselves, and to our bodies. In Cartesian coordinates, if we take our body as the origin of the three axes, we can establish the distinction between *above* and *below*; *left* and *right*; *in front of* and *behind*. Similar reference to our body is inevitably presupposed in the indexical use of geographical maps and the compass.
- (II) Features found in some animal species (e.g., snails' shells) and vegetable ones (e.g., the growth of beans and hops) reveal incongruent counterparts, despite the objects having same size, same proportion, and even same relative positions of their parts.
- (III) Incongruent counterparts seem to play a key role also in the "mechanical organization of the human body", whereby Kant claimed that the majority of people are right-handed, while according to Borrelli and Bonnet, left eyes and left ears have more sensibility.

These three different considerations pave the way to Kant's conclusion that "the ground of the complete determination of a corporeal form does not depend simply on the relation and position of its parts to each other; it also depends on the reference of that

physical form to universal absolute space, as it is conceived by the geometers”.⁵⁵ This is a curious conclusion and my second clue for a more nuanced reading of Kant’s debt to Newton. For it is unclear how points (I)–(III) may work as evidence for absolute space in *Newton’s own sense* (or, for that matter, absolute space as intended by the “geometers”). If anything, the considerations above may work as arguments *against* the “German philosophers” (i.e., Leibniz), who by appealing to relations among parts were unable to account for handedness and chirality. But it is unclear how (I)–(III) could function as arguments *for* Newton’s absolute space itself. Point (I) simply shows the indexical and perspectival nature of spatial representation: it is an epistemic point about our ability to identify directions by locating ourselves onto the map. No distinctive metaphysical thesis about space follows from point (I). Points (II) and (III) can function as arguments against Leibniz, but not necessarily pro-Newton. For it is difficult to see how Newton’s absolute space could possibly enter into an explanation of the chirality of snail shells, hops, beans and the handedness of the human body in any salient way (unless a very weak reading of the claim is given, whereby the role of absolute space is simply reduced to a backdrop against which chirality and handedness become visible and salient, so to speak).⁵⁶ That these incongruent counterparts exist as natural kinds does not begin to show that there must be absolute space to ground them. After all, also under the aforementioned weak reading, absolute space does not seem to be required for us to be able to identify incongruent counterparts. As point (I) makes clear, the perspectival nature of concepts such as *left hand* and *right hand* require only a relation to ourselves and our physical body (not to absolute space) for these concepts to be intelligible. Thus, it would be a *non-sequitur* to conclude from (I)–(III) that one must embrace Newton’s absolute space. If we understand the 1768 text as Kant’s pro-Newton text for absolute space, as the received view has done, we have to construe Kant’s three aforementioned considerations (I)–(III) as new proofs for absolute space (improving where Newton’s and Euler’s own proofs allegedly failed to persuade the “geometers”). But, as indicated above, at best these three considerations simply show that the geometers’ relationalism may face some difficulties in accounting for chirality and handedness. They do not provide compelling evidence for abandoning relationalism in favor of absolutism. In my view, Kant’s 1768 text never meant to endorse Newton’s absolute space, despite the term ‘absolute space’ being used in it. Later readers have read Kant’s *Directions in space* as a

⁵⁵ AA 2: 381. Kant (1768/1992).

⁵⁶ For a perceptive analysis of Kant’s argument, see Earman (1991). For a qualified contemporary defense of Kant’s argument, see Nerlich (1994), ch. 2.

short-lived defense of Newton's absolutism before the Critical turn; but they face the problem of explaining exactly how Kant's remarks above constitute evidence for such an interpretive claim.

That these remarks do not provide evidence for this interpretive claim is corroborated by the fact that there is a third option in between relationalism and absolutism, and the denial of the former does not entail embracing the latter. This is the third and final clue in Kant's text, which in my opinion betrays Kant's qualified debt to Newton. Kant begins the essay by identifying absolute space with the "ultimate foundation of the possibility of the compound character of matter". But this is not the way Newton typically thought of absolute space in the *Principia*. For Newton, absolute space provided the privileged reference frame to define absolute motion. It did not provide the foundation for the compositionality of matter: indeed, the whole problem about the compositionality of matter seems to belong more to metaphysics than to Newton's physics. Hence, the above remark seems more in line with Kant's *Physical Monadology* once again, and the way Kant came to see matter and space as intimately connected, although this time round Kant seemed to speculate that space ought to provide the foundation for the compositionality of matter, rather than the other way around (i.e., space being a consequence of matter filling space in virtue of physical monads as spheres of activity).

The essay closes with the eloquent remark that "absolute space is not an object of outer sensation; it is rather a fundamental concept which first of all makes possible all such outer sensation".⁵⁷ Kant referred to absolute space not as a real object, or substance, but as a *Grundbegriff*, which acted as a pre-condition of our sensible experience, anticipating his mature view of space as an a priori form of sensibility. The reality of space was also said to be "intuitive enough for inner sense", while difficulties arise if we attempt to "philosophise about the ultimate data of our cognition". Absolute space cannot be perceived as an outer object, nor be known as an object of experience. Instead, in remarkable continuity with the two-year later *Inaugural Dissertation*, space was presented as a concept, which makes possible our experience of nature.⁵⁸ The road to the

⁵⁷ AA 2: 383. Kant (1768/1992).

⁵⁸ In the *Inaugural Dissertation*, space is said to be again a "concept...not abstracted from outer sensation" but somehow presupposed in the possibility of outer perceptions (AA 2: 402), and even a "pure intuition...as the fundamental form of all outer sensation" Kant (1770/1992).

Transcendental Aesthetic was still very long. But the groundbreaking path to it had been opened.

4. Conclusion

Newton's legacy for Kant has been the object of sustained scholarly efforts over the past few decades. The *Metaphysical Foundations of Natural Science* have provided the battleground for alternative readings of Newton's influence on Kant. While some scholars have read *MAN* as almost an instantiation of Kant's Transcendental Analytic with the intent of justifying Newtonian mechanics, others have stressed the 'looseness of fit' between Kant's special metaphysics of nature and the transcendental project of the first Critique.

Over the past two decades, Friedman has put forward an alternative reading of Newton's legacy for Kant, especially evident in *MAN*, whereby by rejecting Newton's absolute space, the Critical Kant had to provide an alternative privileged reference frame for absolute motion in terms of the center of mass of the solar system. To this end, Friedman has defended the a priori necessity of Newton's laws of motion and the synthetic a priori nature of Newton's law of gravitation. More to the point, Friedman has interpreted Kant's project in *MAN* as providing the conceptual justification for Newton's mechanics in the absence of Newton's fundamental toolkit (absolute space). An ongoing debate has revolved around Friedman's very influential interpretation, and the peculiar nature of Kant's laws of mechanics in *MAN*, among other aspects.

The purpose of this brief chapter was to shift attention away from the Critical Kant, back to the pre-Critical Kant so as to appreciate the seminal seeds of his mature view. I hope I have achieved my two intended goals. First, to draw attention to the central role that Newton's *Opticks*, with the ensuing experimental tradition that flourished in England with Stephen Hales and in Leiden with Herman Boerhaave played for the young Kant. Newton's matter theory and chemical speculations shaped natural philosophy of the early eighteenth century, and had a profound influence in Kant's development of his own matter theory. My second and related goal was to show that traces of speculative Newtonian experimentalism, suitably blended with a still quasi-Wolffian-Baumgartian metaphysics, underpin the evolution of Kant's view of space in between 1748–1768 (especially evident in *Physical Monadology* and in the treatment of repulsive force).

Far from being an unfailing supporter of Newton's absolute space before turning into a transcendental idealist, the pre-Critical Kant borrowed salient aspects of Wolff's

and Baumgarten's metaphysics, and integrated them with features of a broadly Newtonian matter theory. Space as an external determination of mutually acting physical substances (endowed with primitive attractive and repulsive forces) is a far cry from both Leibniz's monadology and Newton's absolute space. And even in his most representative Newtonian moment (i.e., *Directions in space*), a careful reading reveals gaps in Kant's alleged arguments for a *bona fide* Newtonian absolute space. A lot of work remains to be done to explore the legacy of Newtonian experimentalism on Kant's philosophy of nature. This brief introduction takes only some first, tentative steps into this still largely unexplored territory at the cross-junction of Kantian scholarship and Newtonian studies.

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